

Java spp. had 2 or 4 distinct, purplish spots near the throat of the flower. Plant, leaf, and flowers of the hybrids were intermediate between the parents in size.

A few plants of C26 × C35, C26 × J21C, NG5 × C35, and NG15 × 35 were considered ornamentally superior to their parents.

#### Literature Cited

1. Arisumi, T. 1973. Chromosome numbers and interspecific hybrids among New Guinea *Impatiens* species. *J. Hered.* 64:74-79.
2. ———. 1973. Morphology and breeding behavior of colchicine-induced polyploid *Impatiens* spp. *L. J. Amer. Soc. Hort. Sci.* 98:599-601.
3. Cleveger, S. 1964. A new anthocyanidin

in *Impatiens*. *Can. J. Biochem.* 42:154-155.

4. ———. 1971. Anthocyanidins of some *Impatiens* species. *Evolution* 25:669-677.
5. Jones, K., and J. B. Smith. 1966. The cytogeography of *Impatiens* L. *Kew Bul.* 20:63-72.
6. Jurd, L., and J. B. Harborne. 1968. The structure of aurantinidin. *Phytochemistry* 7:1209-1211.

## Overwintering of Evergreens in Plastic Structures<sup>1</sup>

Harold Davidson and Roy Mecklenburg<sup>2</sup>  
*Michigan State University, East Lansing*

**Abstract.** The overwintering of evergreens without irrigation in plastic structures was best accomplished in a house oriented in a north-south direction and covered with milky polyethylene. Dehydration of evergreens in a structure covered with clear polyethylene and oriented in an east-west direction was attributed to high vapor pressure gradients that occurred in clear days. Evergreens overwintered in structures covered with clear polyethylene should be inspected periodically and irrigated as necessary to prevent desiccation.

Nurserymen in the northern part of the U.S. have found it desirable to utilize various types of storage structures for overwintering plants. Just prior to 1874, I. E. Ilgenfritz of Monroe, Michigan constructed the first nursery storage cellar in the country to protect plants that "would be likely to be injured during the winter if left in the open ground." Another advantage was to facilitate early shipment of plants in the spring (1).

Since the 1960 review of Mahlstede and Fletcher (3) on the storage of nursery stock, a new development in the overwintering of evergreens has been the use of structures covered with polyethylene film (4). This method is popular since the quality of the foliage of plants protected by plastic often is superior to field-overwintered plants and is less expensive than other storage methods. A major problem is that evergreens frequently have been injured when stored under polyethylene. Research was undertaken to identify the factors contributing to successful storage of evergreens in polyethylene (plastic) structures and to provide

recommendations for their use.

In the fall of 1969, 4 plastic houses 3.7 × 2.4 m and 2.1 m high, constructed according to specifications (2), were covered with 4-mil clear polyethylene or 4-mil milky polyethylene film. One house of each type was oriented E-W and N-S. During the first week in Nov., the houses were stocked with 4 species of evergreens: *Taxus cuspidata* Sieb. & Zucc (spreading Japanese yew), *Thuja occidentalis* L. (American arborvitae), *Juniperus chinensis* 'Pfitzeriana' Mast. (Pfitzer juniper) and *Rhododendron catawbiense* Michx. (Mountain rose bay). The *Taxus*, *Thuja* and *Rhododendron* was field dug in early Oct. and put into 25 cm "Kieding" pots. The *Juniperus* were container-grown in 3.7 liter metal pots. Four plants of each species were put into each house. One-half of the plants were mulched with wood shavings placed around and above the containers to a depth of 10 cm.

To obtain leaf temp 6-mil thermocouples were attached to the underside of a *Rhododendron* leaf or inserted into needles of a *Taxus* and *Thuja* about 0.8m above the ground in each house. Air temp was measured by white-colored thermocouples

(insensitive to radiant heating) and a recording potentiometer.

At the end of Nov., when it was certain that the sensing elements were functioning properly, the houses were closed and made as air tight as possible. Inside and outside temp during selected weather conditions were recorded during the winter storage period. When the houses were opened in late March, the physiological condition of each plant was rated on a scale of 1 (dead) to 5 (excellent).

The experiment was repeated in the fall and winter of 1970 with the addition of a recording weekly hygrothermograph in each house. Leaf and air temp were recorded periodically and survival ratings were made after 5 months.

Plant survival was excellent both years in the N-S oriented house covered with milky plastic; all plants survived the storage period in a healthy, vigorous condition (Table 1). Survival was poorest in the E-W house covered with clear plastic; all *Taxus*, *Thuja* and *Rhododendron* were dead. The *Juniperus* were in excellent condition in all houses. In the other 2 houses (milky plastic, E-W and clear plastic, N-S, plant survival was intermediate.

**Temperature.** The differences in house temp were related primarily to building orientation and to the type of polyethylene used (Fig. 1). Houses oriented E-W had a much greater heat buildup than N-S. Milky polyethylene reduced the difference between air and leaf temp and lowered the maximum

Table 1. Effect of house orientation, type of polyethylene film, and mulching on evergreens overwintered in plastic structures.

| Structure orientation | Species             | Physiological rating <sup>2</sup> |           |            |           |
|-----------------------|---------------------|-----------------------------------|-----------|------------|-----------|
|                       |                     | Clear film                        |           | Milky film |           |
|                       |                     | Mulched                           | Unmulched | Mulched    | Unmulched |
| East-West             | <i>Taxus</i>        | 1.0                               | 2.5       | 5.0        | 5.0       |
|                       | <i>Thuja</i>        | 1.0                               | 2.0       | 5.0        | 5.0       |
|                       | <i>Juniperus</i>    | 5.0                               | 5.0       | 5.0        | 5.0       |
|                       | <i>Rhododendron</i> | 1.0                               | 1.5       | 3.2        | 4.0       |
| North-South           | <i>Taxus</i>        | 3.0                               | 5.0       | 5.0        | 5.0       |
|                       | <i>Thuja</i>        | 1.0                               | 5.0       | 5.0        | 5.0       |
|                       | <i>Juniperus</i>    | 5.0                               | 5.0       | 5.0        | 5.0       |
|                       | <i>Rhododendron</i> | 2.0                               | 2.0       | 5.0        | 5.0       |

<sup>2</sup>1 (dead) to 5 (excellent).

<sup>1</sup>Received for publication December 7, 1973. Paper No. 6517 of the Department of Horticulture, Michigan State University Agricultural Experiment Station, East Lansing, Michigan.

<sup>2</sup>The authors thank Mr. Ceel Van Den Brink of the National Weather Service, assigned to Michigan State University, for the loan of portable field instruments.

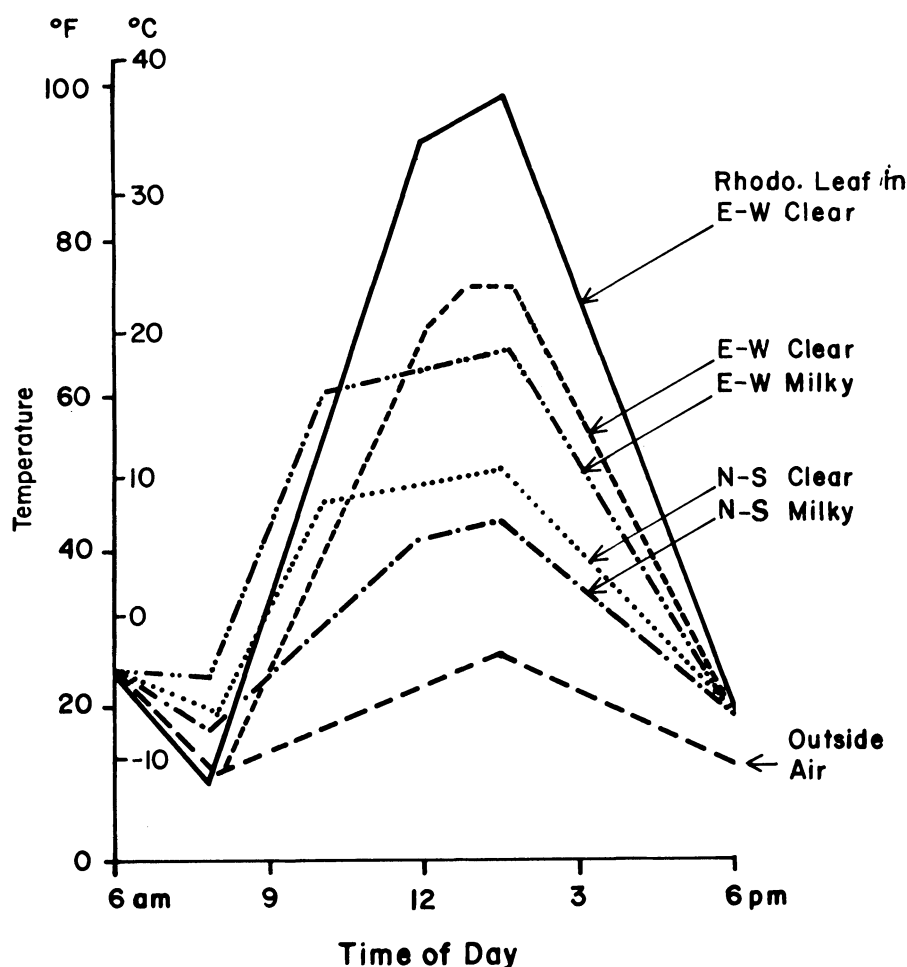


Fig. 1. Representative leaf and air temp occurring on a clear day in winter within plastic structures as affected by structure orientation and type of plastic covering.

leaf and air temp as compared to clear polyethylene. On a clear winter day when the outside air temp was  $-6^{\circ}\text{C}$ , the air temp in the clear, E-W house exceeded  $20^{\circ}$  and leaf temp increased to nearly  $38^{\circ}$ , whereas in the N-S house, covered with milky polyethylene the air temp reached a peak close to  $10^{\circ}$  but the leaf temp did not exceed  $13^{\circ}$ . The average differences between leaf and air temp on clear mid-winter days were  $9^{\circ}$  for the clear E-W,  $5^{\circ}$  for the clear N-S,  $3^{\circ}$  for the milky E-W and  $1.5^{\circ}$  for the milky N-S houses.

**Relative humidity.** The relative humidity fluctuated indirectly with temp above freezing. House air temp of  $-4^{\circ}\text{C}$  and below were accompanied by a relative humidity close to 100% in all houses. The relative humidity dropped as temp increased, reaching a low of 20% when house air temp reached  $37^{\circ}$  in the clear, E-W houses, whereas on the same day the relative humidity

registered a low of 50% for the milky, E-W house with air temp of  $15^{\circ}$ .

**Mulching.** There was no visible effect of mulching upon the storage of the 4 species of evergreens in the milky polyethylene houses. However, mulching of the containers was detrimental to plants stored in the clear polyethylene houses and especially to *Thuja* stored in the N-S house.

**Conclusions.** These results demonstrate that the environment within polyethylene houses used for the winter storage of evergreens was influenced by the compass orientation of the houses and by the clarity of polyethylene covering. Radiant heating from sunlight was greater (during the winter period) in E-W oriented houses than in N-S oriented houses since more radiant energy from the sun penetrated the S side of the house than penetrated the top. Since the E-W house had a

larger S exposed area than the N-S house, it received greater radiant heating. The favorable environment conditions (low temp and high humidity) needed for storage of evergreens came from the structure oriented in a N-S direction and covered with milky plastic. The poorest, environmental condition for storage was in the house oriented E-W and covered with clear plastic.

Plant survival may be explained on the basis of relative transpiration rates that prevailed at various temp and relative humidities within the structures during the storage period. On a clear day in Jan., for example, plants in a clear E-W house with an air temp of  $32^{\circ}\text{C}$ , a relative humidity of 30% and a leaf temp of  $38^{\circ}$  would have a vapor pressure gradient (VPG) of 39mm of Hg, whereas the VPG for plants in a milky, N-S house with a house temp of  $10^{\circ}$ , a relative humidity of 50% and a leaf temp of  $13^{\circ}$  would be 5.6mm of Hg. Thus, the relative transpiration rate of plants in the clear E-W house could be almost 7x greater than those in the milky, N-S house.

Nurserymen storing evergreens during the winter in polyethylene structures should consider the effect that orientation and type of covering will have on the microclimate of the house and adjust cultural practices accordingly. If an E-W orientation is employed with clear polyethylene as the covering, attention must be given to ventilation and irrigation to avoid desiccation of the plants due to high vapor pressure deficits that develop within the structure.

However, evergreens can be overwintered successfully, without irrigation, if the structure is oriented in a N-S direction and covered with milky polyethylene. The vapor pressure deficit is minimized but thawing of the soil and plant tissues is delayed, which will preclude early handling of the plant material.

#### Literature Cited

1. Anon. 1893. Catalog. I. E. Ilgenfritz & Sons, Monroe, Michigan.
2. Davidson, H., and R. Mecklenburg. 1970. A portable polyhouse. *Amer. Nurseryman* 131(10):8.
3. Mahlstede, J. P., and W. E. Fletcher. 1960. Storage of nursery stock. Amer. Assoc. Nurserymen, Washington, D.C.
4. Zelenka, J. 1967. Overwintering evergreens under poly in northern climates. *Proc. Plant Prop. Soc.* 17:351.